State of Utah

GARY R. HERBERT
Governor

GREGORY S. BELL
Lt. Governor

Department of Administrative Services
KIMBERLY K. HOOD
Executive Director

Division of Facilities Construction and Management
DAVID G. BUXTON
Director

ADDENDUM NO. 1

Date: January 13, 2011

To: Design/Build Teams

From: Jeff Wrigley - Project Manager

Reference: Upgrade/Repair Existing HVAC Systems – Salt Lake Data Center
Department of Technology Services – State Office Building – Salt Lake City, Utah
DFCM Project No. 10303300

Subject: **Addendum No. 1**

Pages	Addendum Cover Sheet	1	pages
	Rocky Mountain Energy Analysis Report (February 18, 2010)	28	pages
	SL DC Power Consumption	2	pages
	Salt Lake Monthly UPS Utilization	4	pages
	Total	35	pages

Note: This Addendum shall be included as part of the Contract Documents. Items in this Addendum apply to all drawings and specification sections whether referenced or not involving the portion of the work added, deleted, modified, or otherwise addressed in the Addendum. Acknowledge receipt of this Addendum in the space provided on the Bid Form. Failure to do so may subject the Bidder to Disqualification.

While we contend that SB220 should only be potentially applicable to a contract issued after the effective date of said bill, this is to clarify that for purposes of this contract, regardless of the execution or effective dates of this contract, the status of Utah Law and remedies available to the State of Utah and DFCM, as it relates to any matter referred to or affected by said SB220, shall be the Utah law in effect at the time of the issuance of this Addendum.

1.1 **SCHEDULE CHANGES:** There are no Project Schedule changes.

1.2 **GENERAL ITEMS:** Section 15 of the RFP (page 9) is modified to make the drawings optional rather than required as follows:

- Drawings (optional, 6 sets). Each drawing sheet will be sized sufficient to demonstrate the detail as required to show new design approach, and to demonstrate quality.

Energy Analysis Report

State of Utah Salt Lake Data Center

Located At:
Salt Lake City, UT 84114

Presented to
Daniel Frei
Director Finance
Department of Technology Services
John Harrington
State Energy Manager
Division of Facilities Construction and Management
State Office Building
Salt Lake City, Utah 84114

Sponsored by

ROCKY MOUNTAIN POWER

Energy FinAnswer® Program
Project Number: 8688

Submitted By:

Nexant

February 18, 2010

Disclaimer

The intent of this energy analysis report is to estimate energy savings associated with recommended upgrades to the mechanical systems at the Division of Facilities Construction and Management (DFCM) data center located in Salt Lake City, UT. Appropriate details are provided in Sections 2 through 4 of this report. This report is not intended to serve as a detailed engineering design document and the description of the improvements are diagrammatic in nature only in order to document the basis of cost estimates and savings and to demonstrate the feasibility of suggested improvements. It should be noted that detailed design efforts may be required in order to implement several of the improvements evaluated as part of this energy analysis. As appropriate, costs for those design efforts are included as part of the cost estimate for each measure.

While the recommendations in this report have been reviewed for technical accuracy and are believed to be reasonably accurate, the findings are estimates and actual results may vary. As a result, Nexant and Rocky Mountain Power are not liable if projected estimated savings or economics are not actually achieved. All savings and cost estimates in the report are for informational purposes, and are not to be construed as a design document or as guarantees.

The DFCM data center staff shall independently evaluate any advice or direction provided in this report. In no event will Rocky Mountain Power and/or Nexant be liable for the failure of the customer to achieve a specified amount of energy savings, the operation of customer's facilities, or any incidental or consequential damages of any kind in connection with this report or the installation of recommended measures.

Contacts

Customers:
John Harrington
State Energy Manager
Division of Facilities Construction and Management
State of Utah
4110 State Office Building
Salt Lake City , Utah 84114
P:(801) 652 2888
E: jharrington@utah.gov

Daniel Frei
Director of Finance
Department of Technology Services
State of Utah
1 State Office Building FI 6
Salt Lake City, Utah 84114
P: (801) 538-3459
F: (801) 538-3622
E: dfrei@utah.gov

Rocky Mountain Power:
Chris Kanoff
Energy Efficiency Project Manager
Rocky Mountain Power
825 NE Multnomah, Suite 600
Portland, Oregon 97232
P: (503) 813-5122
E: Christopher.kanoff@pacificorp.com

Gregory Noyes
Customer and Community Manager
Rocky Mountain Power
1569 West North Temple
Salt Lake City, Utah 84116
P: (801) 220-4928
E: greg.noyes@pacificorp.com

Energy Consultant:
Jim Crockett P.E.
Senior Project Engineer
Nexant Inc
4021 South 700 East
Suite 250
Salt Lake City, Utah 84107
P. (801) 639-5603
E: jcrockett@nexant.com

Table of Contents

LIST OF TABLES ..... **V**

1 EXECUTIVE SUMMARY **1**

1.1 INTRODUCTION AND BACKGROUND 1
1.2 SUMMARY OF FINDINGS AND RECOMMENDATIONS 1
1.3 IMPLEMENTATION SUMMARY 4
1.4 GUIDE TO NEXT STEPS FOR THIS PROJECT WITH ROCKY MOUNTAIN POWER 4

2 DETAILED DESCRIPTION OF PROPOSED EQUIPMENT AND OPERATION **5**

2.1 EEM 1: IMPROVE AIRFLOW DISTRIBUTION 5
2.2 EEM 2: INSTALL A WATERSIDE ECONOMIZER 6
2.3 EEM 3: ELIMINATE SIMULTANEOUS HUMIDIFICATION AND DEHUMIDIFICATION 6

3 ENERGY EFFICIENCY MEASURE COSTS **8**

4 ENERGY ANALYSIS METHODOLOGY **9**

4.1 DETERMINATION OF BASELINE ENERGY CONSUMPTION 9
4.2 DETERMINATION OF PROPOSED ENERGY CONSUMPTION 11

5 STRATEGY COMMISSIONING PLAN **14**

5.1 FUNCTIONAL TESTING REQUIREMENTS 14
5.2 MASTER LIST OF DEFICIENCIES 16
5.3 TRENDING REQUIREMENTS 17

6 ROCKY MOUNTAIN POWER ENERGY FINANSWER PROGRAM **22**

7 APPENDIX **23**

List of Tables

Table 1-1: Estimated Rocky Mountain Power Incentive Summary 3
Table 3-1: Cost Components (Option 1 – waterside economizer) 8
Table 4-1: kW Demand Observed at Server Room Liebert Units 11
Table 4-2: kW Demand Observed at Non-Server Room Liebert Units 11
Table 4-3: Proposed HVAC System Usage 13
Table 5-1: EEM Commissioning Summary 14
Table 5-2: Global Input Points 14
Table 5-3: Analog Points 15
Table 5-4: Digital Points 15
Table 5-5: Functional Checklist Log 15
Table 5-6: Master List of Deficiencies 16
Table 5-7: Liebert Measurement Requirements. 20
Table 5-8: Waterside Economizer Measurement Requirements. 20
Table 5-9: Data Center Air Distribution Measurement Requirements. 21
Table 7-1: Energy Savings Calculation 23

1 Executive Summary

1.1 Introduction and Background

The State of Utah Department of Technology Services is consolidating data centers from 27 different locations in to 2 locations, one of which is the Salt Lake City (SLC) data center. This consolidation will reduce the total server count. Data center personnel indicated, in an interview, that it was not yet known whether the net power used in the SLC data center would increase or decrease. Thus, the existing UPS load of approximately 300 kW was used as the basis for calculations in this report.

This Energy Analysis Report (EAR) presents the results of an energy analysis conducted at the facility. The objective of this analysis is to demonstrate the opportunities available to the facility to reduce electricity use through the installation of energy efficiency measures (EEMs) described herein.

Because the existing mechanical system is functional and no upgrade is required, the incentive has been calculated by comparing the proposed system to the existing system.

1.1.1 The Facility

The State of Utah Salt Lake Data Center, located in Salt Lake City, operates 24 hours a day, 7 days per week, and 365 days per year. The Data Center has one floor. It has a raised floor room filled with server racks and other computing equipment. The total area of the data center is approximately 22,000 square feet with 10,900 square feet of raised floor. Air conditioning for the raised floor and supporting areas is provided by direct expansion (DX) Liebert units, which are fed by 6 outdoor dry-cool units which are between 15 and 20 years old.

Nexant has identified an opportunity for the SLC data center to significantly reduce the amount of energy required to cool the data center by taking advantage of evaporative cooling. After implementing hot and cold aisle separation, it is intended that the data center will be cooled with 65˚F supply air which, because of Salt Lake City's arid climate, will be available most of the year through evaporative cooling.

The proposed solution consists of optimizing the airflow within the data center, and reducing the runtime of the compressors in the Liebert units by using a new dedicated cooling tower and heat exchanger to provide chilled water to the Liebert units. When outdoor air conditions permit (more than 90% of the year), the proposed HVAC system will eliminate the power required to run multiple DX units.

1.2 Summary of Findings and Recommendations

The purpose of this EAR is to demonstrate the opportunities available to the SLC data center to reduce electricity use through evaporative cooling. Energy efficiency strategies chosen for inclusion in this report were based on the ISVR provided on December 14, 2009, subsequent site visits, data trended on site, and conversations with data center personnel. A summary of the recommended energy efficiency measures (EEMs) is included in the following section. Details pertaining to the analysis methodology and measure implementation are contained later in this report.

1.2.1 Energy Efficiency Measures

The recommended option was separated into three (3) energy efficiency measures (EEMs). Each has inherent savings that have been calculated using an incremental approach. All of the EEMs must be implemented to realize the projected savings.

1.2.1.1 EEM 1: Improve Airflow Distribution

This measure allows fan savings to be realized by installing physical barriers to separate the cold aisles (on the intake side of the servers) from the hot aisles (on the outlet side of the servers). By keeping the hot and cold air from mixing, the data center can be cooled with warmer supply air, and the Liebert units can cool the same number of servers with less air.

1.2.1.2 EEM 2: Install a Waterside Economizer

If hot and cold aisle separation has been implemented, and the data center can be cooled with warmer supply air (e.g. 65°F instead of 55°F), then installing a cooling tower with a waterside economizer will allow the data center to be cooled without the use of a refrigeration cycle for most of the year. This can result in significant energy savings.

1.2.1.3 EEM 3: Eliminate Simultaneous Humidification and Dehumidification

Data centers are humidified to prevent static electricity problems. However, this often results in humidity being added by a humidifier, and then removed by the cooling coil. Thus, the Liebert unit expends energy dehumidifying the air, and then the humidifiers expend energy humidifying the air. By supplying warmer air to the space and maintaining a warmer cooling coil, simultaneous humidification and dehumidification can be avoided.

1.2.1.4 (Evaluated but not recommended): Install an Airside Economizer

Similar to Option 1, this measure proposes cooling the data center with warmer supply air. However, this measure proposes installing new roof-mounted air handling units (AHUs) with evaporative media, instead of cooling towers and pumps. This type of system costs less to install and operate than the first option, but saves energy a reduced number of hours per year.
This measure is not recommended, because even though air handlers will reduce the compressor energy usage of the seven (7) Liebert units in the server room, the dry-coolers will still be required to run to serve the other five (5) Liebert units.

1.2.2 Economic Summary Tables

Table 1-1 summarizes the energy savings, incremental costs, incentives, and economics of each EEM. The utility cost savings are based on Rocky Mountain Power Rate Schedule 8-Primary. For a more detailed cost breakdown of each EEM, refer to Section 3.

1.2.3 Recommendations and Savings Summary

These measures will save an estimated 839,697 kWh, 66 kW, and $41,548 per year. This results in an estimated simple payback of 7.3 years including Rocky Mountain Power incentives, and is recommended. Note that this payback estimate does not include maintenance or equipment replacement savings.

Table 1-1: Estimated Rocky Mountain Power Incentive Summary

Project Name: State of Utah Data Center

Rocky Mountain Power Rate Schedule: 8

#

Project Status Preliminary

EEM #	Energy FinAnswer Energy Efficiency Measures	Savings: Energy (kWh/yr)	Savings: Demand (kW/mo.)	Savings: Electric Cost ($/yr)	Incremental Installed Cost	Incentive	Payback before incentive	Payback after incentive	EEM Type	Commissioning Required ?
1	Improve Aiflow Distribution	157,444	12	7,790	$76,313	$19,508	9.8	7.3	R	Y
2	Install a Waterside Heat Exchanger	577,291	45	28,564	$279,813	$71,530	9.8	7.3	R	Y
3	Eliminate Simultaneous Humidification and Dehumidification	104,962	8	5,194	$50,875	$13,005	9.8	7.3	R	Y
	Project Total	**839,697**	**66**	**$41,548**	**$407,001**	**$104,044**	**9.8**	**7.3**		

Percentage of cost paid by Incentive: 26% **Installed Cost after Incentive** $302,957 **Incentive** $104,044

Notes regarding Energy FinAnswer incentives:

The above incentives are estimates only. The incentive paid will be based on savings and costs in the post-installation inspection report. The Energy FinAnswer project incentive assumes implementation of all Energy Efficiency Measures. If any measure is not implemented, the available project incentive may change and need to be recalculated. The incentives listed above for individual measures are an allocation of the project incentive (allocated based on savings). For details on how incentives are calculated, see the incentive calculation sheet(s). An incentive agreement needs to be signed prior to making financial commitments to proceed with the project.

1.3 Implementation Summary

This report presents detailed information regarding the energy analysis and assumptions used. Depending upon your organization, one or all of your staff may need to review and understand one or more of the sections of the report. This report is structured as follows:

Section 1 presents an executive summary with an overview of the project.
Section 2 provides a description of the recommended EEMs.
Section 3 outlines the incremental costs associated with each recommendation.
Section 4 details the energy analysis methodology.
Section 5 provides the commissioning plan.
Section 6 contains Rocky Mountain Power's program steps and incentive information.
Section 7 is the appendix.

1.4 Guide to next steps for this project with Rocky Mountain Power

Review this report and make an implementation decision. Your staff has assisted with the development of this report. Because equipment and operational changes are recommended, your organization needs to be comfortable with the data, the analysis and the proposed EEMs for the project to be a success. Please independently evaluate the information contained in this report as you normally would for other projects of this scope. We are here to help – just contact Nexant and/or Rocky Mountain Power. Contact vendors to firm up bids. Do your normal diligence and make a decision.

Sign a Rocky Mountain Power incentive agreement prior to signing Purchase Orders. Contact Rocky Mountain Power with your decision and procurement and installation schedule, and request and sign a Rocky Mountain Power incentive agreement prior to signing purchase orders or making other financial commitments to proceed with the project.

Implement the project. Sign purchase orders and contracts with contractors. Complete the installation. To be eligible for a full incentive, commission the project according to guidelines from Rocky Mountain Power (see Section 5 for the commissioning plan).

Project closeout. Send Rocky Mountain Power written notification of your project installation completion, commissioning submittals, and documentation of costs with labor and material itemized by energy efficiency measure. Rocky Mountain Power will hire a consultant to complete a post-installation inspection and prepare a final inspection report, documenting final energy savings and costs. The incentive payment will be based on the final inspection results.

2 Detailed Description of Proposed Equipment and Operation

The purpose of this EAR is to demonstrate the opportunities available to the State of Utah data center to reduce electricity by upgrading its mechanical system. The proposed mechanical measures were chosen for inclusion in this report based on site visits, trended data, and conversations with data center personnel.

The proposed mechanical system was broken into three energy efficiency recommendations (EEMs). Each EEM has inherent savings. However, the EEMs are interdependent and all measures must be installed in order to achieve the desired savings.

This section provides a high-level overview of the measures. Deviations from these measures will affect the savings and incentives. The customer should evaluate all assumptions and contact Nexant if changes are necessary. Once the selected system has been installed and its operation can be reviewed, the customer will be responsible for conducting on-site tests to determine if the equipment functionality matches the predicted response per the commissioning plan included in Section 5.

Each recommendation is listed in the following sub-sections. Some appropriate parameters and their proposed values are included as a reference for measure implementation and savings verification.

2.1 EEM 1: Improve Airflow Distribution

2.1.1 Source of Energy Savings

Without proper airflow management, servers draw air from the room, heat it, and blow it back into the room. Hot air from the server racks mixes with cold supply air being delivered to the space, resulting in a warmer room temperature. To compensate for this, and to keep the mixed air entering the server racks at an acceptable temperature, data center operators reduce thermostatic set point of the overall data center. This results in the data center being kept cooler than is needed.

Using partitions to physically separate the inlet and outlet sides of the servers (the ‘cold’ and ‘hot’ sides, respectively) prevents hot and cold air from mixing in the room prior to being drawn into the servers. The temperature of the cold aisle will be close to the supply air temperature. The hot air leaving the servers is contained in the hot aisle and returns to the AHU at a warmer temperature. Warmer return air temperatures result in an increased temperature difference across the Liebert unit, and less fan energy being required to deliver the same amount of cooling.

2.1.2 Specific Equipment Recommendations

It is proposed that physical partitions be installed to separate the hot aisles from the cold aisles. This may further include installing barriers to prevent air from passing through gaps or openings in the server racks. Hot aisles will be ducted directly back to the return air intake of the Liebert units. The more isolation between the hot and cold aisles, the more savings can be realized.

To realize the fan savings available from separating hot and cold aisles, it is necessary to add variable frequency drives (VFDs) to the air handler fans. This will allow the fans to slow down, and only provide the required airflow.

2.2 EEM 2: Install a Waterside Economizer

2.2.1 Source of Energy Savings

Currently, the Liebert units are served by a bank of dry-coolers located west of the data center. The Liebert units reject heat into a water / glycol mix which circulates between the dry-coolers and the Liebert units. Each Liebert unit contains two DX compressors that reject heat into the water / glycol loop when cooling is required. When outside air temperatures are sufficiently cold, water from the dry-coolers provides the Liebert units with cooling, without the use of compressors.

With the proposed waterside economizer, the building is cooled without running the Liebert compressors when outdoor air conditions are suitable. Cooling is provided by a cooling tower which cools water to within a few degrees of the outdoor air (OA) wet bulb (WB) temperature. When the OA WB temperature is less than approximately 60˚F, the Liebert units can provide 65°F supply air without running the compressors (approximately 90% of the year).

2.2.2 Specific Equipment Recommendations

The system proposed by the mechanical contractor includes a cooling tower, a waterside heat exchanger, and all required pumps. The equipment is being oversized to achieve an approach temperature of approximately 5°F between the OAWB temperature and the indoor supply air temperature.

2.2.3 Set points Recommended to Achieve Energy Performance

Savings available from this measure depend on the ability of the AHUs to provide supply air temperatures that the server racks can tolerate. It is recommended that the supply air temperature set point be a minimum of 65°F.

2.3 EEM 3: Eliminate Simultaneous Humidification and Dehumidification

2.3.1 Source of Energy Savings

Currently, dehumidification is an unintentional byproduct of cooling the supply air. Dehumidification occurs in the form of condensation when air passes over a surface that is colder than the dew point of the air.

Humidity in the space is maintained at an elevated level, and the temperature of the cooling coil is lower than the mixed air dew point. This causes water to condense on the cooling coil. This dehumidifies the air, and also requires the DX system to expend more energy. Furthermore, it requires the humidifier to expend energy adding humidity back to the air.

Raising the temperature of supply air coil above the dew point temperature of the data center will prevent inadvertent dehumidification. Reducing inadvertent dehumidification

will save energy by reducing the additional cooling required to dehumidify the air, and by eliminating the subsequent re-humidification.

Because the data center has very little human occupancy, its ventilation requirements are minimal. Very little outside air is introduced to the space, so if the supply air temperature is raised enough to prevent dehumidification, very little humidification will be required.

.

3 Energy Efficiency Measure Costs

MSS, a local mechanical contractor with experience on similar projects, visited the site and estimated the costs of installing the proposed measures. The cost of each measure is defined as the investment required to implement the measure. Rocky Mountain Power reserves the right to review invoices and modify the incremental costs for the measures if they change after construction.

The approximate incremental cost associated of adding a waterside economizer is $407,000. The components of this cost estimate are outlined in Table 3-1.

Table 3-1: Cost Components (Option 1 – waterside economizer)

OPTION #1 - WATERSIDE ECONOMIZER

EEM 1: Improve Airflow Distribution

Item	Description	Bidder	Qty	Cost	Total
1	Hot / Cold Aisle Separation	MSS	1	$75,000	$75,000
2	Commissioning	Consultant	1	$1,313	$1,313
Subtotal					**$76,313**
EEM 2: Install a Waterside Economizer					
Item	**Description**	**Bidder**			
1	Oversized cooling tower	MSS	1	$275,000	$275,000
2	Waterside heat exchanger	MSS	1		
3	Primary / Secondary Pumps	MSS	TBD		
4	Commissioning	Consultant	1	$4,813	$4,813
Subtotal					**$279,813**
EEM 3: Eliminate Simultaneous Humidification / Dehumidification					
Item	**Description**	**Bidder**			
1	Raise supply air temperature	MSS	1	$50,000	$50,000
2	Commissioning	Consultant	1	$875	$875
Subtotal					**$50,875**

Total	**$407,000**

Note: Since all measures are required, per-measure commissioniong costs are assumed to be proportional to measure costs.

The following provides specific information regarding the cost estimate for each EEM:

EEM 1:

This includes the costs of physically separating the hot and the cold aisles with physical partitions, and ducting the return air from the hot aisle back the Liebert unit. This was estimated by MSS not to exceed $75,000.

EEM 2:

This includes the costs of installing all cooling towers, heat exchangers, pumps, controls, and other required appurtenances. It further includes the costs of any modifications required to the Liebert units to allow them to accommodate waterside cooling.

EEM 3:

Simultaneous humidification and dehumidification will go away as a natural consequence of raising the supply air temperature in EEM 2. $50,000 the cost of EEM 2 was allocated to EEM 3.

4 Energy Analysis Methodology

Energy savings were calculated by comparing the energy used by the proposed system with the energy used by the existing or baseline system. This section of the report outlines the analysis methodology and results. It is organized by the following sub-sections:

- Section 4.1 describes how the baseline energy consumption was calculated.
- Section 4.2 describes how the proposed energy consumption was calculated.

The proposed measures are all interdependent, and required for the energy savings to be realized. Because of this, the savings were calculated in aggregate for the entire project, and then allocated to each measure according to its cost of implementation.

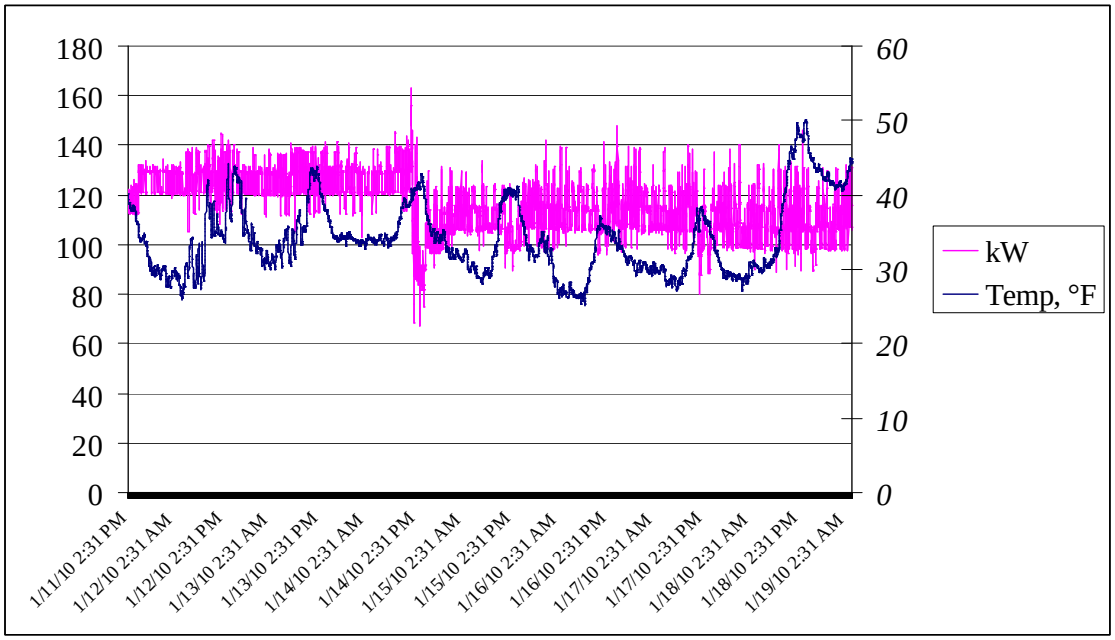
4.1 Determination of Baseline Energy Consumption

Because a mechanical upgrade is optional, the existing system is considered the baseline. The existing dry-cooler system at the State of Utah data center consists of six (6) dry-coolers manifolded together. Water from the dry-coolers is circulated to the indoor Liebert units by six (6) 5 HP pumps. Heat is rejected from the dry-coolers by six (6) 1.5 HP pumps.

In a dry-cooler system, water circulates between indoor Liebert units, and outdoor heat rejection (dry-cooler) units. A direct expansion (DX) cycle in the indoor Liebert units removes heat from return air and rejects it into the water. When outdoor air temperatures (OATs) are sufficiently low, the water from the dry cooler-is cold enough to provide cooling without assistance from the DX compressors.

This system, however, does not appear to be working as intended. On a 30°F day, the water being supplied to the Liebert units was observed to be 60°F. This was not cold enough to allow the Liebert units to run without compressors. As a result of the warm water temperature, the compressors were running. Although there was some variation in the kW demand of the Liebert units, it appeared to be entirely independent of the outdoor air temperature. See Figure 4-1.

Figure 4-1: Server Room Liebert kW vs. OAT



To evaluate the baseline energy usage of the Liebert units, data loggers were installed and data was trended from January 11, 2010 to January 19, 2010. The trended units included all 7 Liebert units in the server room, a Liebert unit in the TOC area, and a Liebert serving the office support area. Three additional Liebert units serving other non-server areas were not trended.

The average demand during the trending period was 117 kW. The OAT during this time period ranged from 25°F to 50°F, and the compressors ran continuously. Because historical utility bills indicate that energy consumption is usually lowest in winter months, the average energy used will generally be higher than 117 kW. However, to be conservative, the average annual energy demand of the Liebert units was estimated to be 120 kW (see Table 4-1).

The baseline energy usage of the Liebert units in the server room is calculated by multiplying the average energy consumption by 8,760 hours per year.

Table 4-1: kW Demand Observed at Server Room Liebert Units

kW	
Trended	**Annual Average (estimated)**
117	120

Data was also trended for two (2) of the five (5) Liebert units outside of the server room. These units serve areas such as the print room, the TOC, and offices. The average kW demand of the trended units was 12.3 kW. The assumption was made that the other three (3) units would have approximately the same demand as the two (2) trended units, resulting in an average usage of 61 kW in January. Although January is likely the worst case scenario, 61 kW was also used as the annual average to be conservative (see Table 4-2).

Table 4-2: kW Demand Observed at Non-Server Room Liebert Units

kW				
Unit #1	**Unit #2**	**Average**	**# of units**	**Total**
17.9	6.7	12.3	5	61

The baseline energy usage of the five (5) Liebert units outside the server room is calculated by multiplying the average energy consumption by 8,760 hours per year.

4.2 Determination of Proposed Energy Consumption

During the vast majority of the year, the OAWB temperature is low enough to allow the Liebert units to supply 65°F air without supplemental cooling from the compressors. During hours when the OAWB temperature is too high for the AHUs units to supply 65°F air using water from the tower, the existing dry-cooler system is available as a backup. No energy savings are claimed during these hours.

It is estimated that the cooling tower and waterside heat exchanger will eliminate the need for the compressors whenever the OAWB is less than 60°F, or approximately 7,982 out of 8,760 hours per year.

The proposed cooling tower fan, according to MSS, will only be required to run when the outdoor air wet bulb temperature is above 45°F. Both the pump serving the cooling tower, and the pump serving the heat exchanger will run year round at full capacity. It is estimated that the Liebert fans will be able to slow down and run at an average speed of

80% of capacity. Because the data center has at least 140 tons of installed capacity, and the heat generated by the equipment on the UPS (i.e. the server racks) is approximately 85 tons, assuming an average load of 80% is conservative.

Because the non-server room Liebert units are used for comfort cooling, the proposed supply air temperature in these areas will be between 50°F and 55°F, rather than 65°F. Because of this, it is assumed that compressor savings will only be realized in the 5 non-server room units when the outdoor air wet bulb (OAWB) temperature is 40°F or less. This represents approximately 4,950 hours or 57% of the year.

The proposed mechanical system will save energy by reducing cooler pump and fan runtime in the outdoor dry-cooler units, and by reducing compressor runtime in the indoor Liebert units.

The proposed energy usage has been summarized in Table 4-3 below.

Table 4-3: Proposed HVAC System Usage

Server Room Proposed HVAC		
Fans	7	fans
	10	HP
	85%	load factor
	80%	average speed
	34.1	**Average kW**
Tower pump	15	HP
	80%	load factor
	9.0	kW
	8760	Runtime hours
	9.0	**Average kW**
CHW pump	15	HP
	90%	load factor
	90%	average speed
	7.3	kW
	8760	Runtime hours
	7.3	**Average kW**
Tower fans	1	fans
	25	HP
	90%	load factor
	80%	average speed
	12.9	kW
	3669	Runtime hours above 50 degrees
	5.4	**Average kW**
Total	**55.7**	**kW**

Non-Server Room Proposed HVAC		
Fans	5	fans
	10	HP
	85%	load factor
	80%	average speed
Total	**24.3**	**kW**

The average energy demand of the new system is (143.2 – 55.7 =) 87.5 kW less than that of the existing system. Operating the new system when OAWB temperatures permit, and running the existing system during the remainder of the year, will result in annual savings of approximately 840,000 kWh per year. (See Table 7-1 in the Appendix for complete energy savings calculations.)

5 Strategy Commissioning Plan

All of the information discussed in this commissioning plan shall be provided and presented in the commissioning report. Table 5-1 summarizes the EEMs that require commissioning or trending.

Table 5-1: EEM Commissioning Summary

EEM #	EEM Name	Require Cx (Y/N)	Require Trending (Y/N)
1	Improve Airflow Distribution	Y	Y
2	Install a Waterside Economizer	Y	Y
3	Eliminate Simultaneous Humidification and Dehumidification	Y	Y

5.1 Functional Testing Requirements

Functional testing shall either be performed by the installing contractor or the commissioning agent. The functional test forms shall be built based on the design sequence of controls for the equipment. They shall also include a point to point check table to compare the control system values to the measured (e.g., temperature sensor) or observed values (e.g., damper position) for each specific EEM. Table 5-2, Table 5-3, and Table 5-4 are examples of the table format used to present the results of the point to point testing. Table 5-5 is an example of the table format to be used for the functional checklist log. These tables should include all of the points that need to be tested for EEMs that required testing.

Table 5-2: Global Input Points

System	Point Name	DDC Value	Measured Value	Pass (Y/N)	Date/CA Initials
Global Parameters	Dry Bulb Temperature				
Global Parameters	Wet Bulb Temperature				

Table 5-3: Analog Points

System	Point Name	DDC Value	Measured Value	Pass (Y/N)	Date/CA Initials
AHUs	Supply Air Temperature				
General	Outside Air Dry Bulb Temperature				
AHUs	Return Air Dry Bulb Temperature				
Plant	Condenser water supply temperature				

Table 5-4: Digital Points

System	Point Name	DDC Value	Measured Value	Pass (Y/N)	Date/CA Initials
Cooling Tower	Cooling Tower Fan Status				
Heat Exchanger	Heat Exchanger Pump Status				

Table 5-5: Functional Checklist Log

EEM #	EEM Name	Control Sequence Received (Y/N/NA)	Completed Functional Checklist Received (Y/N/NA)	Date Received	Received By
1	Improve Airflow Distribution				
2	Install a Waterside Economizer				
3	Eliminate Simultaneous Humidification and Dehumidification				

5.2 Master List of Deficiencies

A closed out deficiency log shall be provided to (from the contractor) or completed by the commissioning agent to demonstrate that any items that did not pass the pre-functional or functional testing have been addressed and mitigated. The trending period shall not commence until all items have been addressed in the deficiency log, there is sufficient loading on the equipment, and the weather is appropriate. The deficiency log shall have a format similar to Table 5-6. A few sample deficiencies are included in the table.

Table 5-6: Master List of Deficiencies

No.	Affected Equipment	Nature of Deficiency	Date Recorded/By Whom	Date that Item is Closed
1	Liebert 1	Supply air temperature sensor is reading 5°F higher than a calibrated measuring device.	1/1/07-NSP	
2	Cooling Tower	During the functional testing, the VFD did not modulate to maintain condenser water temperature.	1/1/07-NSP	
3				

5.3 Trending Requirements

The following section describes the general trending requirements in order to verify the savings of each EEM. Annotated trend graphs should be provided, clearly identifying compliance or non-compliance.

5.3.1 Commissioning – EEM1 – Improve Airflow Distribution

1. Perform 4 weeks of measurements per Table 5-9. It is assumed that the required trended list of points in the table below will need to be collected by the CA using the Building Management System (BMS) or portable data loggers.
2. Evaluate return air, mixed air, and discharge air conditions; and VFD% at the AHU fans (either all, or a representative sample).
3. Verify proper operation of all systems and components, including:
    a. Verify that the fan VFD modulates with the return air temperature to maintain a constant discharge air temperature.
    b. Verify that the temperature of the air entering each of the server racks is acceptable.
    c. Verify that the difference between the RAT and the SAT is greater after implementation of the measure, and that the fan VFD % is lower.
4. Compile data and present results.

Performed by: Date:

Comments/Changes:

5.3.2 Commissioning – EEM2 – Install a Waterside Economizer

1. Perform 4 weeks of measurements per Table 5-7 and Table 5-8. It is assumed that the required trended list of points in the table below will need to be collected by the CA using the BMS or portable data loggers. ***To demonstrate that the waterside heat exchanger eliminates the need for DX cooling, it is important that the 4 weeks of data collection include hot outdoor air temperatures that will allow demonstration of whether supplemental DX cooling is required, or whether the waterside heat exchanger is adequate. Such conditions are most likely to exist on hot summer days.***
2. Evaluate Status and VFD percentages on the water pumps; and discharge air temperature at each air handler (or a representative sample). Verify that the control valve modulates to maintain the discharge air set point. Verify that the pump speeds decrease as the coil demand decreases.
3. Evaluate outdoor air, mixed air, and discharge air conditions; and operation status of fans, waterside heat exchanger, cooling tower, pumps, and valves.
4. Verify proper operation of all systems and components, including:
    a. Verify transition from one cooling mode to another at the appropriate conditions.
    b. Verify that DX cooling equipment activates when the waterside heat exchanger is unable to maintain the discharge air set point.
5. Compile data and present results.

Performed by: Date:

Comments/Changes:

5.3.3 Commissioning – EEM3 – Eliminate Simultaneous Humidification and Dehumidification

1. Perform 4 weeks of measurements per Table 5-7 and Table 5-9. It is assumed that the required trended list of points in the table below will need to be collected by the CA using the BMS or portable data loggers.
2. Evaluate the return air and supply air humidity levels, and verify that humidification and dehumidification are not occurring at the same time.
3. Verify proper operation of all systems and components, including:
    - *a.* Verify that humidification is provided at the appropriate conditions.
    - *b.* Verify that dehumidification is provided at the appropriate conditions.
4. Compile data and present results.

Performed by: Date:

Comments/Changes:

Table 5-7: Liebert Measurement Requirements.

Point	Units	Frequency	Duration
Return Air Temperature – Drybulb	°F	5 minute	Minimum four-week period
Return Air Relative Humidity	%	5 minute	Minimum four-week period
Amperage of Liebert unit	Amps	5 minute	Minimum four-week period
Discharge Air Temperature-Drybulb	°F	5 minute	Minimum four-week period
Air Handler Status	On/Off	State change	Minimum four-week period
Condensing Unit Status	On/Off	State change	Minimum four-week period
Condensing Unit Amperage	Amps	5 minute	Minimum four-week period

Table 5-8: Waterside Economizer Measurement Requirements.

Point	Units	Frequency	Duration
Outside Air Temperature-Drybulb and Wetbulb	°F	15 minute	Minimum four-week period
Cooling water supply temperature	°F	15 minute	Minimum four-week period
Cooling water return temperature	°F	15 minute	Minimum four-week period
Cooling water pump status	On/Off	State change	Minimum four-week period
Cooling water pump amperage	Amps	15 minute	Minimum four-week period
Cooling water pump speed (VFD %)	%	15 minute	Minimum four-week period
Cooling tower status	On/Off	State change	Minimum four-week period
Cooling tower LWT	°F	15 minute	Minimum four-week period

Table 5-9: Data Center Air Distribution Measurement Requirements.

Point	Units	Frequency	Duration
Air temperature entering server racks (measured at various locations)	°F	5 minute	Minimum four-week period
Space relative humidity	%	15 minute	Minimum four-week period

6 Rocky Mountain Power Energy FinAnswer Program

- Implementation decision and sign incentive agreement

  Review the content of the Energy Analysis report and make a decision on implementation. Rocky Mountain Power and our engineering consultant are available to answer questions.
  Contact Rocky Mountain Power to discuss your decision and implementation schedule. Request an incentive agreement if you plan to proceed with implementation.
  To be eligible for incentives, sign the Rocky Mountain Power Incentive Agreement prior to signing purchase orders for equipment.

- Procurement, installation and commissioning

  Provide Rocky Mountain Power with copies of purchase orders/signed contracts with installers by the date specified in your incentive agreement.
  Contact Rocky Mountain Power during project implementation if there are changes affecting the energy savings potential of the project, the project cost, or the schedule.
  Complete the installation and provide written notice of completion to Rocky Mountain Power by the date specified in your incentive agreement.
  Complete commissioning according to plan provided by Rocky Mountain Power. (The customer pays for commissioning as part of the implementation cost of the measures.)

- Post-installation inspection and incentive payment

  Provide Rocky Mountain Power with commissioning submittals and project invoices. Documenting costs by energy efficiency measure with labor and material itemized.
  Rocky Mountain Power (or a consultant hired by Rocky Mountain Power) will contact you to schedule an inspection of installed energy efficiency measures.
  Rocky Mountain Power will review the inspection results, commissioning submittals, and invoices. Rocky Mountain Power will mail an incentive payment within 45 days of satisfactory review of the inspection results and project invoices.

7 Appendix

Table 7-1: Energy Savings Calculation

Server Room Liebert Demand		
Baseline HVAC	143.2	kW
Proposed HVAC	55.7	kW
Average Savings	87.5	kW
# of months w/ demand savings	9	
# months w/out demand savings	3	
Average kW savings	**66**	**kW**
# of hours w/ existing system	778	(wb >= 60°F)
# of hours w/ new system	7982	
Non-Server Room Liebert Demand		
Baseline HVAC	61.5	kW
Proposed HVAC	24.3	kW
Average Savings	37.1	kW
# of months w/ demand savings	0	
# months w/out demand savings	12	
Average kW savings	**0**	**kW**
# of hours w/ existing system	4951	(wb >= 40°F)
# of hours w/ new system	3809	
Consumption		
Baseline Consumption	1,793,118	kWh
Proposed HVAC	537,648	kWh
Existing HVAC	415,773	kWh
Savings	**839,697**	**kWh**
Cost per kWh	$ 0.0365	Schedule 8 primary
Cost per kW	$ 13.8020	Schedule 8 primary
Incentive per kWh	$0.12	
Incentive per average kW	$50	
Annual Utility Savings	**$ 41,548.38**	
Incentive	$104,043.90	
Total Cost	$ 407,000	
Net Cost	$ 302,956	
Simple Payback	**7.3 years**	

Note: This payback only includes energy savings. Other savings such as maintenance and equipment reqplacement costs have not been included.

Server Room Proposed HVAC		
Fans	7	fans
	10	HP
	85%	load factor
	80%	average speed
	34.1	**Average kW**
Tower pump	15	HP
	80%	load factor
	9.0	kW
	8760	Runtime hours
	9.0	**Average kW**
CHW pump	15	HP
	90%	load factor
	90%	average speed
	7.3	kW
	8760	Runtime hours
	7.3	**Average kW**
Tower fans	1	fans
	25	HP
	90%	load factor
	80%	average speed
	12.9	kW
	3669	Runtime hours above 50 degrees
	5.4	**Average kW**
Total	**55.7**	**kW**

Non-Server Room Proposed HVAC		
Fans	5	fans
	10	HP
	85%	load factor
	80%	average speed
Total	**24.3**	**kW**

SL DC Power Consumption

Yy	Mo.	Kilowatt Energy Use
2006	January	394459.74
2006	February	360252.51
2006	March	394841.46
2006	April	391569.18
2006	May	412958.01
2006	June	406168.02
2006	July	432169.62
2006	August	431490.48
2006	September	400845.12
2006	October	410678.28
2006	November	395013.57
2006	December	385997.97
2007	January	412,721.58
2007	February	369,451.56
2007	March	383,985.81
2007	April	405,518.61
2007	May	428,553.72
2007	June	434,819.09
2007	July	464,674.77
2007	August	468,250.47
2007	September	433,085.85
2007	October	285,107.64
2007	November	341,008.24
2007	December	444,689.00
2008	January	200,108.73
2008	February	402,717.33
2008	March	401,301.36
2008	April	422,076.00
2008	May	421,409.00
2008	June	451,639.00
2008	July	480,180.00
2008	August	516,242.00
2008	September	454,152.00
2008	October	446,594.84
2008	November	423,134.00
2008	December	425,050.00
2009	January	425,719.19
2009	February	388,354.00
2009	March	434,163.52
2009	April	425,891.25
2009	May	453,760.39
2009	June	449,934.00
2009	July	486,123.00
2009	August	469,622.00
2009	September	452757.09
2009	October	461,246.32
2009	November	443725.96
2009	December	457993.43
2010	January	441666.16
2010	February	393987.31
2010	March	458037.94
2010	April	473707.61

2010	May	504533.03
2010	June	506784.27
2010	July	534780.00
2010	August	535377.05
2010	September	501664.51
2010	October	489981.79
2010	November	467898.92
2010	December	488889.8

Salt Lake Monthly UPS Utilization

Note: *Each UPS is designed to carry the entire load if the other UPS fails. Since they are 225 kw redundant system , each UPS should not be loaded to the maximium of 112 kW. Stats are pulled every Monday kw* ***Output*** *.*

MGE 225 kva (200kw) # 3					MGE 225 kva (200kw) # 4							
Date	Total kw Capacity	Used kw	Spare kw	% Available	Date	Total kw Capacity	Used kw	Spare kw	% Available	Date	Total kw both	% Used
07/07/08	112	0	112	100%	07/07/08	112	0	112	100%	07/07/08	0	0%
07/14/08	112	0	112	100%	07/14/08	112	0	112	100%	07/14/08	0	0%
07/21/08	112	0	112	100%	07/21/08	112	0	135	121%	07/21/08	0	0%
07/28/08	112	3	109	97%	07/28/08	112	1	111	99%	07/28/08	4	1%
08/04/08	112	1	111	99%	08/04/08	112	1	111	99%	08/04/08	2	1%
08/11/08	112	3	109	97%	08/11/08	112	1	111	99%	08/11/08	4	1%
08/18/08	112	2	110	98%	08/18/08	112	1	111	99%	08/18/08	3	1%
08/25/08	112	2	110	98%	08/25/08	112	1	111	99%	08/25/08	3	1%
09/01/08	112	2	110	98%	09/01/08	112	1	111	99%	09/01/08	3	1%
09/08/08	112	2	110	98%	09/08/08	112	1	111	99%	09/08/08	3	1%
09/15/08	112	2	110	98%	09/15/08	112	1	111	99%	09/15/08	3	1%
09/22/08	112	2	110	98%	09/22/08	112	1	111	99%	09/22/08	3	1%
09/29/08	112	2	110	98%	09/29/08	112	1	111	99%	09/29/08	3	1%
10/06/08	112	2	110	98%	10/06/08	112	1	111	99%	10/06/08	3	1%
10/13/08	112	2	110	98%	10/13/08	112	3	109	97%	10/13/08	5	2%
10/20/08	112	2	110	98%	10/20/08	112	3	109	97%	10/20/08	5	2%
10/27/08	112	2	110	98%	10/27/08	112	2	110	98%	10/27/08	4	1%
11/03/08	112	2	110	98%	11/03/08	112	1	111	99%	11/03/08	3	1%
11/10/08	112	2	110	98%	11/10/08	112	2	110	98%	11/10/08	4	1%
11/17/08	112	3	109	97%	11/17/08	112	1	111	99%	11/17/08	4	1%
11/24/08	112	3	109	97%	11/24/08	112	1	111	99%	11/24/08	4	1%
12/01/08	112	4	108	96%	12/01/08	112	2	110	98%	12/01/08	6	2%
12/08/08	112	4	108	96%	12/08/08	112	2	110	98%	12/08/08	6	2%
12/15/08	112	4	108	96%	12/15/08	112	2	110	98%	12/15/08	6	2%
12/22/08	112	4	108	96%	12/22/08	112	2	110	98%	12/22/08	6	2%
12/29/08	112	3	109	97%	12/29/08	112	3	109	97%	12/29/08	6	2%
01/05/09	112	4	108	96%	01/05/09	112	3	109	97%	01/05/09	7	3%
01/12/09	112	4	108	96%	01/12/09	112	3	109	97%	01/12/09	7	3%
01/19/09	112	4	108	96%	01/19/09	112	2	110	98%	01/19/09	6	2%
01/26/09	112	4	108	96%	01/26/09	112	2	110	98%	01/26/09	6	2%
02/02/09	112	4	108	96%	02/02/09	112	4	108	96%	02/02/09	8	3%
02/09/09	112	4	108	96%	02/09/09	112	4	108	96%	02/09/09	8	3%
03/02/09	112	5	107	96%	03/02/09	112	5	107	96%	02/16/09	10	4%
04/04/09	112	7	105	94%	04/04/09	112	6	106	95%	02/23/09	13	5%
04/18/09	112	8	104	93%	04/18/09	112	6	106	95%	03/02/09	14	5%
05/02/09	112	7	105	94%	05/02/09	112	6	106	95%	03/09/09	13	5%
05/16/09	112	7	105	94%	05/16/09	112	5	107	96%	03/16/09	12	4%

05/31/09	112	8	104	93%	05/31/09	112	8	104	93%	03/16/09	16	6%
06/13/09	112	10	102	91%	06/13/09	112	8	104	93%	03/16/09	18	7%
7/5/09	112	11	101	90%	07/05/09	112	11	101	90%	03/16/09	22	8%
07/19/09	112	13	99	88%	07/19/09	112	11	101	90%	03/16/09	24	9%
08/02/09	112	13	99	88%	08/02/09	112	13	99	88%	03/16/09	26	10%
08/16/09	112	14	98	88%	08/16/09	112	14	98	88%	03/16/09	28	10%
08/30/09	112	14	98	88%	08/30/09	112	13	99	88%	03/16/09	27	10%
09/27/09	112	14	98	88%	09/27/09	112	13	99	88%	03/16/09	27	10%
10/04/09	112	13	99	88%	10/04/09	112	13	99	88%	03/16/09	26	10%
10/18/09	112	20	92	82%	10/18/09	112	19	93	83%	03/16/09	39	14%
11/01/09	112	20	92	82%	11/01/09	112	21	91	81%	03/16/09	41	15%
11/22/09	112	25	87	78%	11/22/09	112	25	87	78%	03/16/09	50	19%
12/13/09	112	25	87	78%	12/13/09	112	24	88	79%	03/16/09	49	18%
12/27/09	112	26	86	77%	12/27/09	112	24	88	79%	03/16/09	50	19%
01/03/10	112	28	84	75%	01/03/10	112	25	87	78%	03/16/09	53	20%
01/17/10	112	28	84	75%	01/17/10	112	24	88	79%	03/16/09	52	19%
02/07/10	112	29	83	74%	02/07/10	112	28	84	75%	03/16/09	57	21%
02/21/10	112	29	83	74%	02/21/10	112	28	84	75%	03/16/09	57	21%
03/07/10	112	30	82	73%	03/07/10	112	28	84	75%	03/16/09	58	21%
03/21/10	112	33	79	71%	03/21/10	112	34	78	70%	03/16/09	67	25%
04/11/10	112	39	73	65%	04/11/10	112	41	71	63%	03/16/09	80	30%
04/25/10	112	39	73	65%	04/25/10	112	40	72	64%	03/16/09	79	29%
05/09/10	112	43	69	62%	05/09/10	112	42	70	63%	03/16/09	85	31%
05/23/10	112	42	70	63%	05/23/10	112	42	70	63%	03/16/09	84	31%
06/06/10	112	43	69	62%	06/06/10	112	42	70	63%	03/16/09	85	31%
06/27/10	112	45	67	60%	06/27/10	112	44	68	61%	03/16/09	89	33%
07/11/10	112	48	64	57%	07/11/10	112	47	65	58%	03/16/09	95	35%
07/25/10	112	46	66	59%	07/25/10	112	46	66	59%	03/16/09	92	34%
08/08/10	112	44	68	61%	08/08/10	112	44	68	61%	03/16/09	88	33%
08/22/10	112	48	64	57%	08/22/10	112	47	65	58%	03/16/09	95	35%
09/05/10	112	44	68	61%	09/05/10	112	46	66	59%	03/16/09	90	33%
09/19/10	112	46	66	59%	09/19/10	112	45	67	60%	03/16/09	91	34%
10/03/10	112	46	66	59%	10/03/10	112	47	65	58%	03/16/09	93	34%
10/17/10	112	46	66	59%	10/17/10	112	47	65	58%	03/16/09	93	34%
10/31/10	112	46	66	59%	10/31/10	112	45	67	60%	03/16/09	91	34%
11/14/10	112	44	68	61%	11/14/10	112	44	68	61%	03/16/09	88	33%
12/29/10	112	46	66	59%	12/29/10	112	47	65	58%	03/16/09	93	34%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%
	112	0	112	100%		112	0	112	100%	03/16/09	0	0%

	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%
	112	0	112	100%			112	0	112	100%	03/16/09	0	0%